DESIGN AND OPERATIONAL ANALYSIS OF VIRTUAL CELLULAR MANUFACTURING SYSTEMS

A brief outline of the area of research work proposed to be carried out in pursuance of the requirements for the award of

Degree

of

DOCTOR OF PHILOSOPHY

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1. INTRODUCTION

Virtual Cellular Manufacturing (VCM) has been proposed as a way to overcome the aforementioned shortcomings of both CM and functional layouts. With VCM, groups of resources are again dedicated to the manufacturing of a part family, but these cells are not reflected in the layout of the manufacturing system. Machines remain in their functional layout: the cells are instead formed in the planning and control system and have a temporary nature (Hyer and Brown, 1999). As such, VCM combines the robustness and flexibility of process orientation with the advantages of product orientation, and this is expected to realize favorable throughput time performance. In so doing, it provides opportunities to improve performance in situations where a cellular layout is technically infeasible.

Some of the important definitions for VMC as framed by the eminent researchers in the past are as follows:

McLean, Bloom and Hopp (1982):

"The virtual cell […] is no longer identifiable as a fixed physical group of machines, but rather as a computer process, associated data and a dynamically changing set of workstations on the shop floor."

Irani, Cavalier and Cohen (1993):

"… virtual cells […] allow time sharing of work stations with other virtual cells that produce different part families, but have overlapping resource requirements. Computer control, supported by a flexible handling system allows the set of work stations in the shop floor to be dynamically reconfigured."

Kannan and Ghosh (1996):

"Virtual cellular manufacturing is the formation of temporary virtual cells where family-based scheduling rules are used to form logical cells within a shop using a process layout".

Ko and Egbelu (2003):

"Virtual manufacturing cells are simply logical cells in which the machines belonging to the same cell need not occupy the same contiguous area. Because cell members are logical instead of physical, machines in a cell can be at any location on the floor."

Slomp, Chowdary and Suresh (2005):

"…, virtual cells are addressed as temporary groupings of machines, jobs and workers to realize the benefits of CM."

Caprihan, Slomp, Srivastava, Agarwal (2010):

"The virtual cells are a logical grouping of workstations which is only present in the planning and control system and in the minds of workers. Virtual cells are created periodically in response to changes in demand, and this imparts VCM systems their characteristic dynamic nature."

2. LITERATURE REVIEW

In recent years, there has been a consistently high level of interest in the design and operation of many new types of manufacturing cells (e.g., virtual cells, holonic cells, dynamic cells, etc.). Among these VMCs proposed nearly two decades ago, appears to be of increasing interest to researchers lately.

In a VMC, a group of resources may be dedicated to the manufacturing of a part family, though this grouping may not be reflected in the physical structure of the manufacturing system. Depending on the job mix at a given time, machines across various departments may be identified as virtual (logical) groups, instead of physically repositioning the machines to be adjacent to each other. This avoidance of change in shop layout has been a major feature of many definitions offered for VMCs over the years. Traditional cellular layouts, involving physical repositioning of machines, have also been subject to several years of controversy regarding their relative advantage over functional layouts (Suresh, 1991, 1992; Suresh and Meredith, 1994). In addition to some doubts on their performance, the limited adoption of CM by industry has also been pointed out as an indication of its restricted applicability in practice (Wisner and Sifer, 1995). The increasing attention given to VMCs lately has also been driven by such factors (Nandurkar and Subash Babu, 1998; Subash Babu, Nandurkar and Thomas, 2000).

Identifying logical groups of resources, within the production control system, offers the possibility of achieving the advantages of CM in situation where traditional CMS may not be feasible. The resulting advantages may include improved flow performance, higher efficiency, simplified production control and better quality.

VMCs make use of this principle by distinguishing groups of resources in the production planning and control stage that may not be reflected in the layout. This prevents the need for costly and time-consuming reorganization of the shop floor and allows for quick response to changing circumstances.

Now that the feasibility of VMCs as an alternative to both the functional and cellular layout is being established, there is a need to review the current status of this research area.

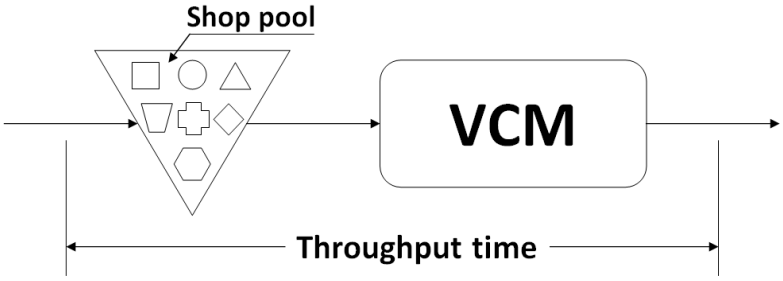
3. OBJECTIVES OF THE PROPOSED RESEARCH

3.1 Objective 1:

Based on the extant review, it is clear that most research has focused on static VCM design issues. However, given the fact that the true benefits of VCM are best exploited in a dynamic sense, the following design issues will be addressed:

i. What should be the frequency of periodic review before the redesign is attempted?
ii. What should be the period length?
iii. What should be the size of shop pool of jobs/parts when (re-)designing the VCMSs?

It is anticipated that the answers to these questions will help in optimizing performance measures including production output and shop throughput/ delivery times.



3.2 Objective 2:

The literature review also revealed that past research primarily focused attention on non-due date based performance analysis of VCMSs and that due date based research was rather scant. In this objective therefore, we will focus attention on the development and testing of family-based dispatching/ scheduling rules so as to optimize due date based measures of VCMSs performance.

3.3 Objective 3:

As mentioned in Objective 1 above, thus far, research has only addressed static forms of VCMS design, that is, the application of family-based scheduling rules in non-cellular layouts. In such cases, VCM emerges automatically as a result of operational decisions, but only at a *local* level. Information on jobs elsewhere in the factory is not used in such a case. A possible extension would be the development of look-ahead strategies, where knowledge of future job arrivals (thus jobs that are already somewhere else in the factory) is used to control the assignment of part families to machines. The use of information theoretic based (Shannon, 1948a, 1948b) entropic methods can also be explored in this context. It is hoped that this study objective will help in organizing the VCM shop floor so that better *globally* optimized performance will result.

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